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DESIGN FOR ASSEMBLY

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Abstract

Today in industrial world there is no place for conventional methods of communication between design and manufacturing. In order to achieve right design at the very first time, designers are required to ensure that their products meets functional requirements and are easy to assemble and manufacture. Software tools of today have had substantial success in improving the communication between design and manufacturing. Design for Assembly has emerged as one of important tool which has enabled identification of potential assembly and manufacturing problems during the design stage. Design for Assembly is also playing important role in providing suggestions to designers on how to eliminate these problems.

Index Terms: *Computer aided Design, Design for Assembly, and Design for Manufacturing*

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1. INTRODUCTION

Design for Assembly is a process by which products are designed with ease of assembly in mind. If a product contains fewer parts it will take less time to assemble, thereby reducing assembly costs. In addition, if the parts are provided with features which make it easier to grasp, move, orient and insert them, this will also reduce assembly time and assembly costs. The reduction of the number of parts in an assembly has the added benefit of generally reducing the total cost of parts in the assembly. This is usually where the major cost benefits of the application of design for assembly occur.

Design for Assembly (DFA) techniques are methods used by today's engineers in order to minimize the time spent, and therefore minimize the cost, to assemble a product. It is well establish fact now that nearly 25% to 50% of the total cost of manufacturing a product is spent on assembly. Over the years, many DFA techniques have been established in an attempt to minimize the amount of assembly time for manufactured products.

In this literature survey attempt has been made to gather information on various research made in the field of Design for Assembly.

2. LITERATURE SURVEY

Most early work on assembly analysis was rule-based design attributes of the components, the assembly operations and relationships between components were used to estimate the ease or difficulty of assembly of components. These rule-based approaches represented a breakthrough over the existing state of the art. Currently, however more plan based evaluation systems are being developed in order to better reason about situations where the particular assembly sequence greatly affects assimilability [1]

The pioneering work of Boothroyd and Dewhurst 2 in developing the design for assembly guidelines has resulted in several automated assembly evaluation and advisory systems. The research on Design for Assembly is pioneered by Boothroyd and Dewhurst and is based on the premise that the lowest assembly cost can be achieved by designing a product in such a way that it can be economically assembled by most appropriate assembly system. There are three basic types of assembly systems namely manual, special purpose machine and programmable machine assembly. Boothroyd and Dewhurst provided a Product Design for Assembly Handbook (Boothroyd and Dewhurst, 1986) indicating ratings for each part in the assembly, based on the part's ease of handling and insertion. The techniques described in this handbook are concerned with minimizing cost of assembly within the constraints imposed by the other design features of the product. Using the Design for Assembly computer program provided, a designer answers a series of questions about the fastening method, symmetry of parts, size of the parts and angle of insertion. The evaluation obtained in terms of assembly time and assembly efficiency can be used to reveal the required design changes from the viewpoint of assembly.

The method developed by Boothroyd and Dewhurst(1987) can be summarized as follows:

1. Through the use of basic criteria, the existence of each separate part is questioned and the designer is required to provide the reasons why the part cannot be eliminated or combined with other.
2. The DFA index (design efficiency) is obtained by comparing the actual assembly time.
3. The actual assembly time is estimated using a database of real time standards developed specifically for the purpose.
4. Assembly difficulties are identified which may lead to manufacturing and quality problems.

Swift [3] also presented a methodology similar to that of Boothroyd and Dewhurst. Another effort in this direction was made by Jakiela and Papalambros who developed a design advisory system by integrating a rule-based system with a CAD system. Jakiela's system provides a library of predefined features with which the designer can create a design, when new features are added to the design, the system makes use of production rules to evaluate the design and offers suggestions for improving it. In this approach the designer creates parts using the features offered by the library, working incrementally and as the design progresses, offering advice at every design step. Hence the design improvement suggestions are strongly influenced by the sequence in which the designer enters various features.
De Fazio and Whitny [4] represented one of the first efforts to develop possible assembly sequence and selecting suitable ones using manufacturing information. They identify liaisons between components of the assembly. The liaison represents connections or relations between assembly components, usually in the form of physical contact like snaps and screws. From these liaisons, assembly precedence are identified and used to determine the feasibility assembly sequences. The assembly sequences are generated from a disassembly state by adding components until a final assembly is generated in most cases their algorithm generates multiple alternative sequences. The determination of precedence constraints is an interactive process and their methodology does not obtain them directly from a solid model. The algorithm needs to be extended to extract the liaison automatically for use in an automated assemblability evaluation system.

Although the Hitachi Assemblability System was not initially computerized, over time it has served as a basis for development of an automated assemblability system. The Hitachi methodology is based upon the principle of one motion per part; there are symbols for each type of assembly operation and penalties for each operation based on its difficulty. Finally the method computes as assembly evaluation a core and an assembly-cost ratio. This assembly-cost ration gives an indication of cost per operation. By studying these results one can identify the sources of bad assemblability and, after modifications to the designs are made, these metrics can be computed to find the degree of improvement. The methodology is common for manual, automatic and robotic systems.

Warnecke and Bassler studied both functional and assembly characteristics. Parts with low functional value but high assembly difficulty receive low scores, while parts with high functionality and low assembly cost receive high scores. The scoring is used to guide the redesign process.

Miles and Swift [5] developed an assembly evaluation method in which parts are divided in to two groups based on functional importance: category A parts are required from the design specifications and category B parts are accessories. The goal of the method is to eliminate as many category B parts as possible through redesign. Analyses of feeding and fitting are carried out on the parts, with both results combined into a total score. This total is divided by the number of category A parts in order to calculate a final score. A proposed assembly sequences is used to perform fitting analysis.
Sturges and Kilani have developed a semi automated assembly evaluation methodology that attempts to overcome some of the limitations of the scheme proposed by Boothroyd and Dewhurst. Currently, while lacking geometric reasoning capabilities their system serves as an interactive environment to study the effect of various design configurations on assembly difficulty.
Li and Hwang [6] did a study of design for assembly and developed a semi automated system which closely follows the Boothroyd-Dewhurst methodology. The analysis of assembly difficulty and cost estimation modules is a direct computer implementation of the

DFA rules. Their methodology considers multiple assembly sequence and calculates the time for all of the feasible sequences. They perform limited feature recognition for assembly and obtain from the user the non geometric information that will affect the assembly. Hsu et al. developed an approach to design for assembly that examines and evaluates assembly plans using three criteria: parallelism, assemblability and redundancy. They evaluate assembly plans in an attempt to find problems with the assembly and when possible, introduce modifications to improve the plan. If a better plan is found, the design is modified by splitting, combining or perturbing various components. This system is one of the first approaches in plan based assemblability evaluation and redesign suggestion generation for assembly. There are limitations to this approach and compared to the work of Boothroyd and Dewhurst, their assemblability evaluation criteria are restricted. They do not consider tolerance and surface finish issues and can only suggest minor modifications to design.

3. ASSEMBLY ORIENTED DESIGN PROCESS

Assembly oriented design involves coordinating assembly level and part level design in a top down manner. Generally the top down design advances the process from the conceptual level, preliminary level to the detailed level. There are two aspects to be involved in conversion of requirement in to a design. One of these aims at permitting a designer to hook a set of machine elements together to form a system, analyze and evaluate them, design them by CAD. The other is more conceptual and is intended to permit a designer to think up new configurations of functions and parts and to look at them from the assembly process point of view. The whole procedure of assembly oriented design is as shown below

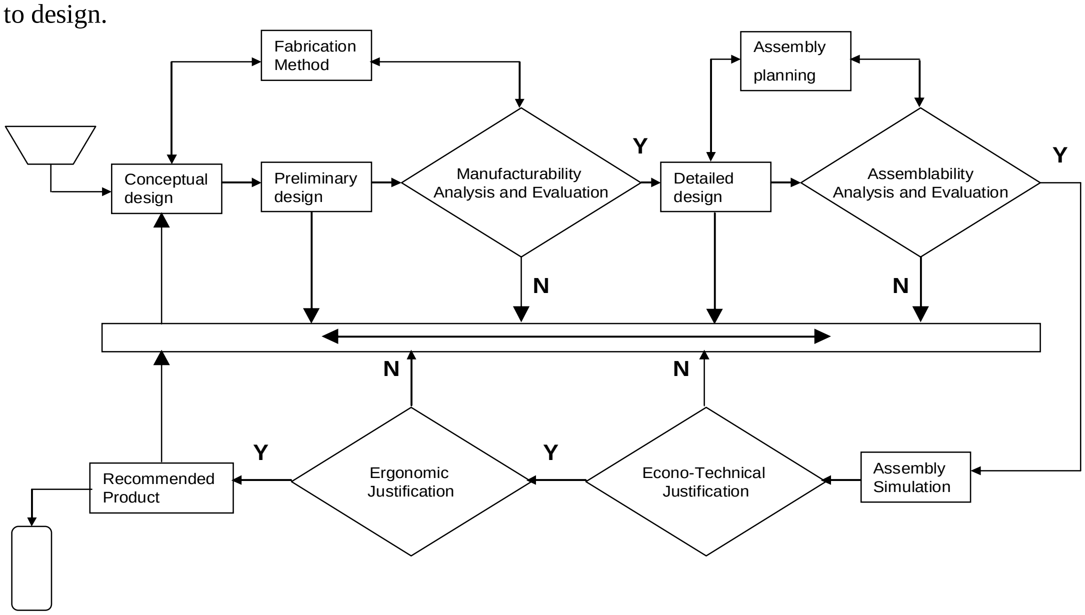

Fig. 1 – Integrated Assembly Oriented Design

4. USE OF CAD TOOLS

The availability of low cost computational power is providing designers with a variety of CAD tools to help increase productivity and reduce time consuming build test redesign iterations. Nowadays CAD is mainly used for detailed engineering of 3D models and/or 2D drawings of physical components; it is also used throughout the engineering process from conceptual design and layout of products, through strength and dynamic analysis of assemblies to definition of manufacturing methods of components. It is well established that Design for Assembly will be delivered through computer based tools. Many of the features in CAD tools help optimize the manufacturing assembly process. For instance, the ability of the assembly modeler to furnish information on interferences and clearances between mating parts is particularly useful.

Such information would enable the designer to eliminate interference between two mating parts where it is impractical to provide for an interference based on physical assembly requirements. This activity can be accomplished within the modeling program, thereby averting any productivity loss that might occur when interferences are detected on the shop floor.

5. ASSEMBLY MODELE

Assembly part files point to geometry and features in the subordinate parts rather than creating duplicate copies of those objects at each level in the assembly [4]. This technique not only minimizes the size of assembly parts files, but also provides high levels of associativity. Geometric changes made at any level within an assembly result in the update of associated data at all other levels of affected assemblies. An edit to an individual piece part causes all assembly drawings that use that part to be updated appropriately.

6. CONCULSIONS

Design for Assembly methodologies were developed to support the designer by generating feedback on the consequences of design decisions on product assembly. The aim is to help the designer to produce an efficient and economic design. The application of Design for Assembly guides the designer towards a product with an optimum number of parts, that requires simple, cost-effective assembly operations and the most appropriate manufacturing processes and materials for its components. Furthermore assembly modeling is an extension of geometric modeling that facilitates the construction, modification, and analysis of complex assemblies. Parts and components are added to an assembly by specifying mating conditions or assembly constraints. The resulting assembly model can then support various types of analysis such as design for assembly, kinematic analysis, dynamic analysis, and tolerance analysis. Assembly modelers permit a battery of virtual engineering tests to be conducted on an assembly prior to manufacture, helping to lower costs and optimize the overall design and manufacturing process.

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